ABSTRACT

Modern transportation systems face challenges in providing right-of-way priority for emergency vehicles to ensure timely and safe arrival at their destinations. Delays caused by conventional traffic light control systems may increase travel time for emergency responders, negatively impacting the effectiveness of critical response efforts.

This research proposes a multimodal emergency vehicle detection system that integrates siren-based audio analysis and visual detection using the YOLOv5 algorithm. The system is implemented on an edge computing architecture using a Raspberry Pi, enabling real-time processing of audio signals and camera imagery. A servo motor is utilized to dynamically adjust the camera's field of view, while detection results are used to control an adaptive traffic light cycle.

Laboratory testing indicates that the visual detection system achieves an average accuracy of over 87% with an inference time of approximately 35 milliseconds per frame. The audio module responds to siren signals within an average of 40 milliseconds at prototype scale distances. Experimental results demonstrate that the system can effectively assign traffic signal priority based on emergency vehicle detection and operates reliably under controlled simulation conditions.

Keywords: adaptive traffic light control, edge computing, emergency vehicle detection, multimodal sensing, raspberry pi, real-time processing, yolov5